APPLICATION

FOR

UNITED STATES LETTERS PATENT

Be it known that we, Shi-Chang Wooh, residing at 5 Moore Circle, Bedford, MA 01730 and being a citizen of Korea; and Peter Testa, residing at 9 Washington Avenue, Cambridge, MA 02140 and being a citizen of U.S.A., have invented a certain new and useful

BUILDING CONSTRUCTION AND METHOD USING TENSION SUPPORT MEMBERS

of which the following is a specification:

FIELD OF THE INVENTION

This invention relates to a building construction and method using tension or tensile support members.

RELATED APPLICATIONS

This application is based on U.S. Provisional Application Serial No. 60/281,510 filed on April 4, 2001, entitled METHOD AND PROCEDURE FOR TOP DOWN CONSTRUCTION OF VERTICAL BUILDINGS AND STRUCTURES USING COMPOSITE MATERIALS.

BACKGROUND OF THE INVENTION

Advanced composite materials, such as fiber reinforced plastics (FRP), primarily developed in aerospace defense and other industries, are finding more applications in civil engineering and architecture and they emerge as attractive future construction materials. Structures made of these materials enjoy a host of benefits because they are stiff, strong, light and formable. However, their use in buildings and other civil structures is currently limited due to inherent design requirements. Most traditional structural design concepts allow for the transmission of forces to the ground through compression members distributed throughout the structure. Therefore, many buildings are constructed utilizing steel-reinforced concrete as their compression members, which provide high compressive strength. Although composites inherently have high specific stiffnesses and

strengths, their structural performance under compressive loads could be degraded dramatically due to a variety of reasons.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide an improved building construction and method.

It is a further object of this invention to provide such an improved building construction and method which utilizes tension support members.

It is a further object of this invention to provide such an improved building construction and method which uses to advantage the stiff, strong, light and formable qualities of composite materials.

It is a further object of this invention to provide such an improved building construction and method which is easier and quicker.

It is a further object of this invention to provide such an improved building construction which admits of a top down building approach to suspend components in tension.

The invention results from the realization that a new and beneficial building construction and method which makes use of the qualities of composite materials to provide lighter, stronger structures can be achieved by using a core support structure such as one or more columns for sustaining a support beam, linear or curved, to support one or more tension members from which are suspended one or more enclosure cells which also can be made of composite materials.

This invention features a building construction using tension support members

including a support structure for bearing a compressive load and a support beam borne by the structure. There is at least one enclosure cell and at least one tension member for suspending an enclosure cell from the support beam.

In the preferred embodiment the support structure may include a column, or two columns, or three or more columns. The support beam may include a linear beam, an annular beam, a number of linear beams, or an inner and an outer annular beam with an interconnection structure between them. The tension member may include a cable element, there may be a number of cable elements suspending each enclosure cell. The tension member may include a fiber reinforced plastic material; the enclosure cell may include a wall and a floor and may be made of fiber reinforced plastic material.

This invention also features a method of building using tension support members providing a support structure for bearing a compressive load, installing a support beam on the support structure; providing at least one enclosure cell; and suspending each enclosure cell with a tension member from the support beam.

In the preferred embodiment additional enclosure cells may be suspended from the support beam, the support structure may include at least two columns, or three or more. The support beam may be a linear beam or an annular beam or maybe a combination of an inner and an outer annular beam with an interconnection structure between them.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in

which:

Fig. 1 is a side elevational view of a building construction using tension support members according to this invention;

Fig. 2 is a top plan view of the building construction shown in Fig. 1;

Fig. 3 is an enlarged three-dimensional view of an enclosure cell of Fig. 1;

Figs. 4A and 4B show alternative methods of interconnecting the suspension cable to the enclosure cell of Fig. 3;

Fig. 5 is a three-dimensional view of another form of an enclosure cell, similar to that shown in Fig. 3, but having a different arrangement for interconnection with the suspension cables;

Fig. 6 is a top plan view similar to that of Fig. 2 showing the attachment of the suspension cables for accommodating the enclosure cell of Fig. 5;

Fig. 7 is a schematic three-dimensional view showing an alternative technique for suspending an enclosure cell from the support beam using a suspension cable;

Fig. 8 is a three dimensional view of the building constructed according to this invention in which the support structure includes three columns and the support beam includes an annular beam;

Fig. 9 is a top plan view of another embodiment of a building constructed according to this invention in which the support structure includes three columns, wherein the annular beam which bears the cables that suspend the enclosure cell are outside of the periphery of the columns and another circular beam resting on the columns supports the outer annular beam;

Fig. 10 is a top plan view of an enclosure cell usable with the building

construction of Fig. 9;

Fig. 11 is a top plan view of another embodiment of the invention in which the support structure includes three columns and the support beam includes an annular ring which is inside of the periphery of the columns and supports an enclosure cell by means of cables which are bridged through the annular beam;

Fig. 12 is a view similar to Fig. 11 wherein the annular ring has been replaced with a triangular arrangement of linear beams;

Fig. 13 is a view similar to Figs. 9, 11, and 12 in which the support structure includes four columns and the support beam includes four linear beams, or in the alternative may include eight columns and an annular beam;

Fig. 14 is a view similar to Fig. 1 showing an alternative technique for using the tension cable to support the enclosure cells from the support beam;

Fig. 15 is a side schematic elevational view of another embodiment of this invention in which one or more enclosure cells are suspended by tension cables from opposite sides of the support beam so that they balance each other; and

Fig. 16 is a top plan schematic view of a device similar that shown in Fig. 15 with two support beams each supporting opposing balanced enclosure cells.

DISCLOSURE OF SPECIFIC EMBODIMENT

There is shown in Fig. 1 the building construction 10 according to this invention including support structure 12, having two columns 14 and 16, mounted on foundations 18 and 20 on the ground 22. Borne by the columns 14 and 16 is a support beam 24 comprised in this case of a linear beam 26. There is at least one 28 and typically

additional successive enclosure cells 30, 32 suspended from linear beam 26 by means of tension members, cables 36, 38, 40, 42, 44, 46, 48. These are mounted in any suitable fashion to linear beam 26 such as for example by eyebars 50, 52, 54, 56, 58, 60 and 62. The tension members, or cables 36-48 may be made of any suitable material which is strong in tension although not so strong in compression, for example, steel or composite materials such as carbon or Kevlar or glass or boron. An enclosure cell can actually include an entire level or story of a large high rise building of 40, 50, or 100 stories where each level, or story, includes a number of halls and rooms.

Linear beam 26 and columns 14 and 16 may be conventional steel reinforced concrete capable of bearing conventional compressional loads. Linear beam 26, Fig. 2, may include a plurality of holes 64, 66, 68, 70, 72, and 74 through which cables 36-48 pass. Each enclosure cell represented by enclosure cell 28, Fig. 3, may include a wall 76 and floor 78 made of a composite material such as steel or other composite materials using carbon, Kevlar, glass or boron or glass reinforced plastics or honeycomb composites. Cables 38 and 46 which suspend enclosure cell 28 from beam 26 may be fastened to the floor of enclosure cell 28 by means of an anchor plate 80, Fig. 4A, or cables 38 and 46 may constitute legs of a continuous loop of cables Fig. 4B, one portion of which 82 passes through the floor 78 along the bottom of the floor and back through the floor emerging as cable 46.

Alternatively, basket 28a, Fig. 5, may include a plurality of hooks 90, 92 on each side through which a cable 94, 96 is continually woven. Alternatively, cable 94 could move through only the first two hooks and then rise as shown at 94a. Its other end 94b would pass through the other two hooks and rise as shown at 94c. Similar alternatives are

available with cable 96 as indicated at 96 a, b, and c, with respect to hooks 92. For suspending enclosure cell 28a, beam 26, Fig. 6, may include eyebars 100 and 102 for securing cable 96 and eyebars 104 and 106 for securing cable 94. Although only three ways have been shown of attaching the cable between the support beam and enclosure cell, this is not a limitation of the invention. There is any number of ways available, for example, as shown in Fig. 7 a cable 110 may be laced alternatively between the eyebars 112 on support beam 26a and the eyebars 114 on enclosure cell 28aa. A similar construction would apply for cable 116 laced through eyebars 118 and 120.

While the embodiment disclosed thus far, beginning in Fig. 1, employs the support structure of only two columns, this is not a necessary limitation of the invention and in fact for more stability a support structure using three or more columns is preferred, as shown in Fig. 8, where the three columns 130, 132, and 134 bear a support beam in the form of annular beam 136 which secures through anchor plates 138 a plurality of tension members or cables 140 that suspend enclosure cell 142. Although in Fig. 8 the annular beam 136 which supports the cables is shown borne directly on the supporting columns 130, 132, and 134 this is not a necessary limitation of the invention, for as shown in Fig. 9, the annular beam 136a may be larger and disposed outside of the columns 130, 132, and 134 and supported by an intermediate structure such at truss 142 attached to the inner annular beam 144. Any interconnection support structure could be used in place of a more complex truss: radial beams, chord beams etc… In that case the basket 28b may extend beyond the periphery of annular beam 136a and it may, as shown in Fig. 10, include three clearance holes 150, 152 and 154 to accommodate columns 130, 132, and 134. The support beam, annular beam 160, Fig. 11, may be disposed inside of the

columns 130, 132, 134 and the cables 162, 164, and 166 which suspend enclosure cell 28c may have sections 168, 170, 172 which bridge clearance holes in annular beam 160 and are anchored to enclosure cell 28c and subsequent cells. More likely additional cables will be used which will suspend additional successive enclosure cells. For safety, each enclosure cell may be supported by more than one cable or cable assembly so that if one cable breaks one or more others will still function to support the enclosure cell.

The invention is not limited to annular beams; for example, as shown in Fig. 12 the support beam 24a actually includes three linear beams 26', 26'' and 26''' which form a triangle resting on columns 130, 132, 134 to support one or more enclosure cells 28d using cables 180, 182 and 184 as explained previously which lap beams 26', 26'', 26''' for suspension.

The invention is not limited to three columns to implement the support structure, any number of columns may be used; as shown in Fig. 13, four columns 190, 192, 194, 196 may be used to support four beams 198, 200, 202, 204 or, alternatively, additional columns may be added, for example columns 206, 208, 210, and 212 and the support beam may be implemented in the form of annular beam 214.

The straightforward suspension of the enclosure cells from the support beam using suspension cables is not a limitation of the invention. Any approach that uses the cables, which may be formed of composite materials intended to support enclosure cells which also may be formed of composite materials is contemplated. For example, as shown in Fig. 14, a structure similar to that shown in Fig. 1 wraps a cable 220 around linear beam 26d on columns 14d and 16d to suspend enclosure cell 28d from beam 26d. Enclosure cell 30d may be suspended in the same way by wrapping cable 222 around it

and support beam 26d. Additional strength and support can be achieved by applying a coating of adhesive to and anchoring the cables.

Although, thus far, all of the embodiments use a support structure that has two or more columns, this is not a necessary limitation of the invention. For example, as shown in Fig. 15, the support structure may be implemented with a single column 230 carrying a linear beam 232 from which is suspended enclosure cell 234 by means of cable 236 laced, for example, as shown in Figs. 5 or 7. Additional enclosure cells 236, 238 may be suspended in the same way. In opposition to these one or more enclosure cells 234, 236, and 238 there is a balancing mass of enclosure cells 240, 242, 244 which are attached in the same way by cable 246. By maintaining the two sides in balance, a stable building platform is achieved. This can be embellished as shown in Fig. 16, where there are two linear beams 250, 252 each of which carries an opposed balance set 254, 256, 258, 260, respectively, of enclosure cells.

Although specific features of the invention are shown in some drawings and not in others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention. The words “including”, “comprising”, “having”, and “with” as used herein are to be interpreted broadly and comprehensively and are not limited to any physical interconnection. Moreover, any embodiments disclosed in the subject application are not to be taken as the only possible embodiment.

Other embodiments will occur to those skilled in the art and are within the following claims:

What is claimed is: